Consultative Committee for Thermometry (CCT) Strategy and Initiatives for Metrology on Climate Change

Dr Yuning DUAN

CCT President and CIPM member

(NIM – China)

2015-10-29

Bureau International des Poids et Mesures

Bureau International des Poids et Mesures

– the intergovernmental organization through which Member States act together on matters related to measurement science and measurement standards.

Search facility:

Consultative Committee for Thermometry (CCT)

The CCT was set up in 1937. Present activities concern matters related to the establishment and realization of the International Temperature Scale of 1990 (ITS-90) and thermodynamic temperature, extension and improvement of the ITS-90, secondary reference points, and international reference tables for thermocouples and resistance thermometers. The Committee is also charged with establishing international equivalence between national humidity standards and the improvement of transfer standards for humidity measurements.

President:
Dr Y. Duan
Vice Director
National Institute of Metrology
China

Executive Secretary:
Dr S. Picard
Bureau International des Poids et Mesures
France

Summary of the CCT meeting 2014

CCT summary

Open documents

CCT Strategy http://www.bipm.org/en/committees/cc/cct/

- Redefinition of Kelvin and Thermodynamic temperature measurement
- MeP-K
- Meet the requirments of the stakeholders in the areas of Energy (supply and security) , Global warming , High-value manufacturing ,Health, safety and security

The stakeholder´s needs are currently dominated by the following challenges:

- Energy (supply and security) – through supporting sustainable generation, increasing the amount of renewables and low carbon dioxide generation methods (e.g. nuclear, carbon capture storage [CCS]) in the energy mix and supporting energy efficiency measures through improved thermal efficiency and utilisation of energy.

- Global warming - aiming to reduce carbon dioxide emissions, transition to a low carbon economy whilst in the short to medium term improve monitoring measures including establishing traceability for data series. Temperature is the fundamental quantity involved in a wide range of climate change investigations.

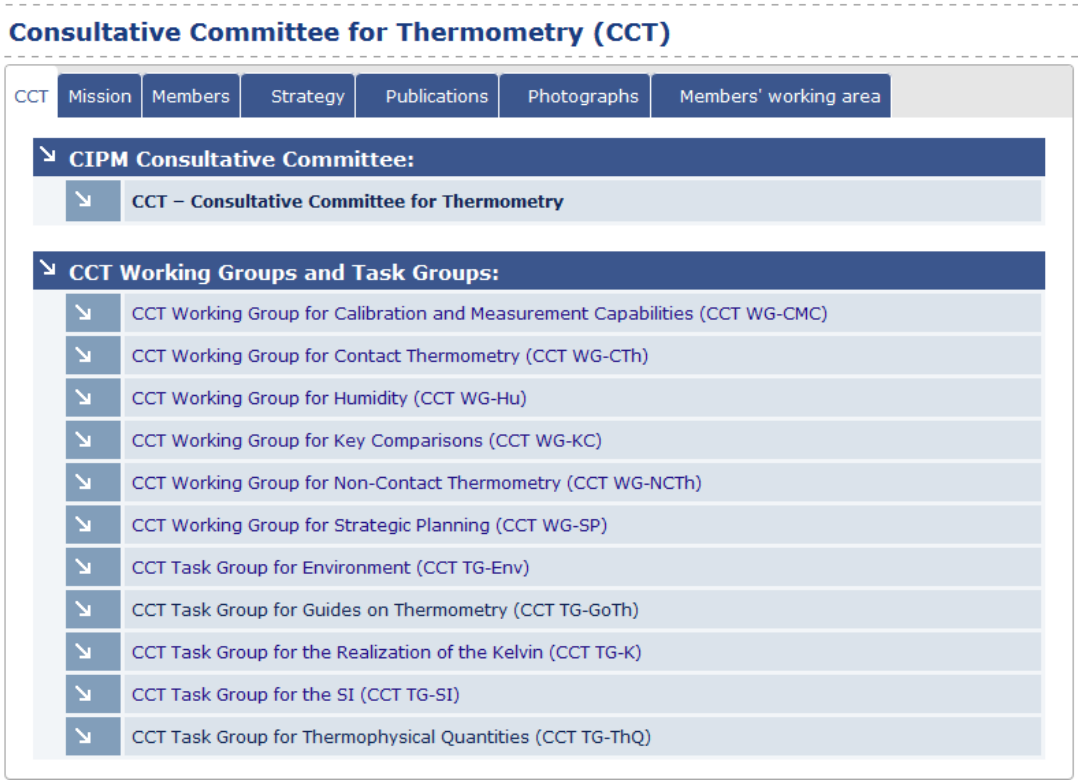
- High-value manufacturing – in particular enhancing competitiveness through optimum use of resources (raw materials and energy) and improving process control to facilitate "zero waste" manufacture and improved product quality, lifetime, and user benefits. In the longer term increasing computer power (through quantum computing) is a potential growth industry in the future requiring accurate temperature measurement at very low temperatures.

- Health, safety and security –advanced traceable temperature measurements are required in hospitals for safe active thermal therapies (e.g. cancer ablation) and in ports of access (buildings and boarders) for pandemic control.

CCT meeting : WG reform

- Working Group Reform adopted by the CCT
  - 10 → 6 Working Groups **submitted to the CIPM for approval**
  - 5 → 5 objective oriented Task Groups

    of which one is a newly created TG on Environment



CCT Strategy

http://www.bipm.org/en/committees/cc/cct/

- Redefinition of Kelvin and Thermodynamic temperature measurement
- MeP-K
- Meet the requirments of the stakeholders in the areas of Energy (supply and security) , Global warming , High-value manufacturing ,Health, safety and security

CCT meeting : Boltzmann constant

- Progress on the determination of the Boltzmann constant for a future re-definition of the kelvin

Acoustic Gas Thermometry

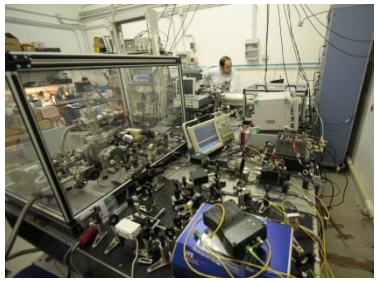
$$u_0^2 = \gamma kT / m \quad \gamma = c_p/c_V$$

Dielectric Constant Gas Thermometry

$$\Delta\nu_D = [2\ kT/(mc_0^2)]^{1/2} \square\ \nu_0$$

Johnson Noise Thermometry

$$\langle U^2 \rangle = 4\ kT\ R\ \Delta\nu$$



Doppler Broadening Thermometry

$$p = kT\ \varepsilon_0\ (\varepsilon_r - 1)/\alpha_0$$

Bureau International des Poids et Mesures

CCT meeting : Boltzmann constant

Recommendation T 1 (2014) to the CIPM:

(extract)

recommends

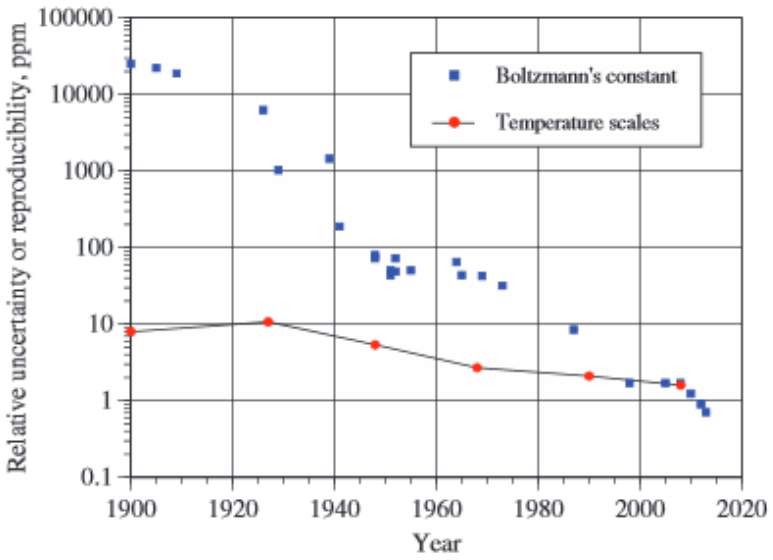
that the CIPM requests the CODATA to adjust the values of the fundamental physical constants, from which a fixed numerical value of the Boltzmann constant will be adopted, when the following two conditions are met:

- the relative standard uncertainty of the adjusted value of k is less than 1×10^{-6};
- the determination of k is based on at least two fundamentally different methods, of which at least one result for each shall have a relative standard uncertainty less than 3×10^{-6}.

metrologia

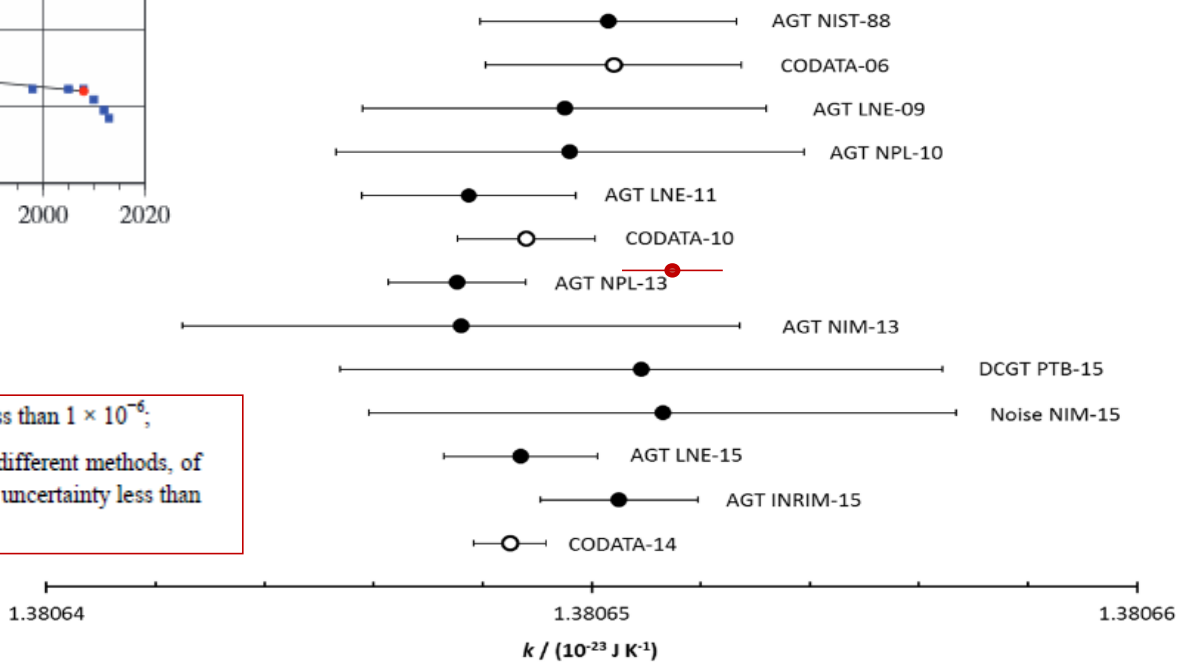
International journal of quantum and applied metrology

Focus on the Boltzmann constant



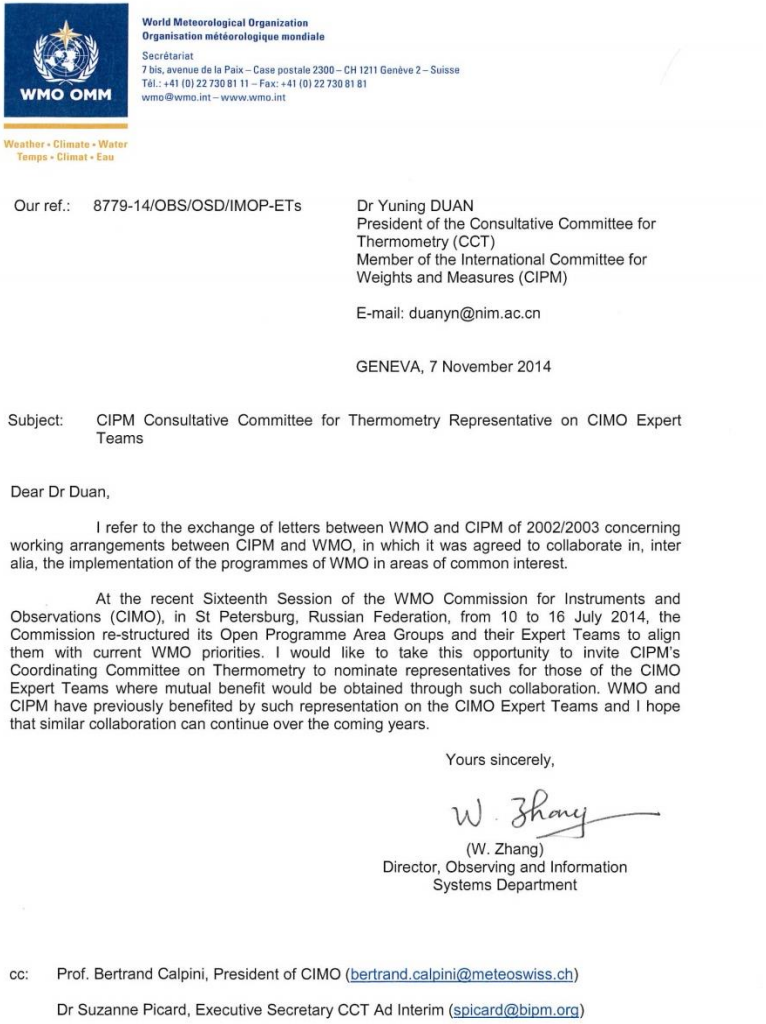
1. the relative standard uncertainty of the adjusted value of k is less than 1×10^{-6};
2. the determination of k is based on at least two fundamentally different methods, of which at least one result for each shall have a relative standard uncertainty less than 3×10^{-6}.

CURRENT STATUS



9

Climate Change: WMO-CIMO collaboration



World Meteorological Organization
Organisation météorologique mondiale

Secrétariat
7 bis, avenue de la Paix – Case postale 2300 – CH 1211 Genève 2 – Suisse
Tél.: +41 (0) 22 730 81 11 – Fax: +41 (0) 22 730 81 81
wmo@wmo.int – www.wmo.int

WMO OMM

Weather • Climate • Water
Temps • Climat • Eau

Our ref.: 8779-14/OBS/OSD/IMOP-ETs

Dr Yuning DUAN
President of the Consultative Committee for Thermometry (CCT)
Member of the International Committee for Weights and Measures (CIPM)

E-mail: duanyn@nim.ac.cn

GENEVA, 7 November 2014

Subject: CIPM Consultative Committee for Thermometry Representative on CIMO Expert Teams

Dear Dr Duan,

I refer to the exchange of letters between WMO and CIPM of 2002/2003 concerning working arrangements between CIPM and WMO, in which it was agreed to collaborate in, inter alia, the implementation of the programmes of WMO in areas of common interest.

At the recent Sixteenth Session of the WMO Commission for Instruments and Observations (CIMO), in St Petersburg, Russian Federation, from 10 to 16 July 2014, the Commission re-structured its Open Programme Area Groups and their Expert Teams to align them with current WMO priorities. I would like to take this opportunity to invite CIPM's Coordinating Committee on Thermometry to nominate representatives for those of the CIMO Expert Teams where mutual benefit would be obtained through such collaboration. WMO and CIPM have previously benefited by such representation on the CIMO Expert Teams and I hope that similar collaboration can continue over the coming years.

Yours sincerely,

W. Zhang

(W. Zhang)
Director, Observing and Information Systems Department

cc: Prof. Bertrand Calpini, President of CIMO (bertrand.calpini@meteoswiss.ch)

Dr Suzanne Picard, Executive Secretary CCT Ad Interim (spicard@bipm.org)

Commission for Instruments and Methods of Observations (CIMO) of the WMO

Members of CCT TG on Environment nominated to join 5 identified CIMO Expert Teams (CEM, IMGC, NPL, PTB?)

1 CIMO member on the TG-Env

Bureau International des Poids et Mesures

Consultative Committee for Thermometry / Dr Yuning DUAN

*

Climate Change

TG-Environment took part of the BIPM Workshop in June on *Global to Urban Scale Carbon Measurements* by the contribution from Dr Peter Thorne (WMLO GCOS Reference Upper Air Network): ” Impact of GHGs: Measuring global temperature change”.

TG-Environment organizes a Break-out-session at the Arctic Circle General Assembly on Iceland on 18 October 2015 : “Metrology for Environment in the Arctic”, endorsed by the BIPM (letter from Dr M. Milton for the opening) and the CCT.

Energy

- Key comparisons are considered for thermal conductivity, heat flux density, and heat capacity of bulk materials, generated by the demand of high-performance insulating materials to reduce energy consumption.

- Since thermal diffusivity, specific heat capacity and thermal conductivity of thin films are key quantities for thermal management of electronics industry and nanotechnology, pilot studies or supplementary comparisons should be considered.

- Thermal expansion coefficient up to high temperatures; Hemispherical total emissivity; Thermal diffusivity and specific heat capacity of thin films;Thermal conductivity of bulk materials;Thermal conductivity of insulation materials; Combustion enthalpy of fuels;Fusion enthalpy of heat storage material;Thermal resistance of vacuum insulation panel.

CCT meeting of May 2014

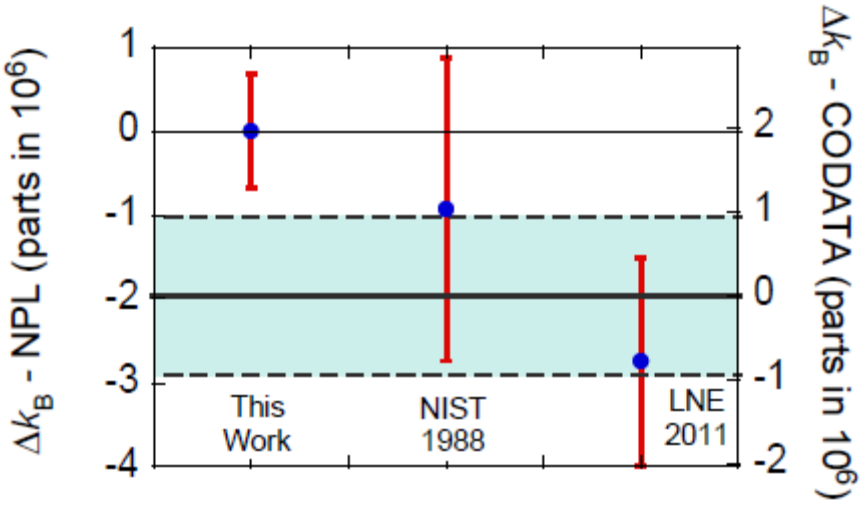
Thank you

CCT meeting : Boltzmann constant

Method	gas	up to 2011	2013	2014	institute
AGT	Ar	-	-	20 ppm	CEM+UVa
AGT	He	7.5 ppm	-	?	INRiM
AGT	He	2.7 ppm	-	0.9 ppm	LNE-CNAM
AGT	Ar	1.2 ppm	-	?	LNE-CNAM
AGT	Ar	7.9 ppm	3.7 ppm	3 ppm	NIM
AGT	Ar	3.1 ppm	0.7 ppm	-	NPL
DCGT	He	7.9 ppm	4.3 ppm	2 ppm ?	PTB
JNT	-	-	-	3 ppm ?	NIM
JNT	-	12 ppm	-	6 ppm ?	NIST
JNT	-	-	-	< 20 ppm ?	NMIJ
DBT	NH_3	50 ppm	-	< 10 ppm ?	LPL+LNE-CNAM
DBT	H_2O	160 ppm	24 ppm	< 10 ppm ?	UniNA+INRiM

CCT meeting : Boltzmann constant

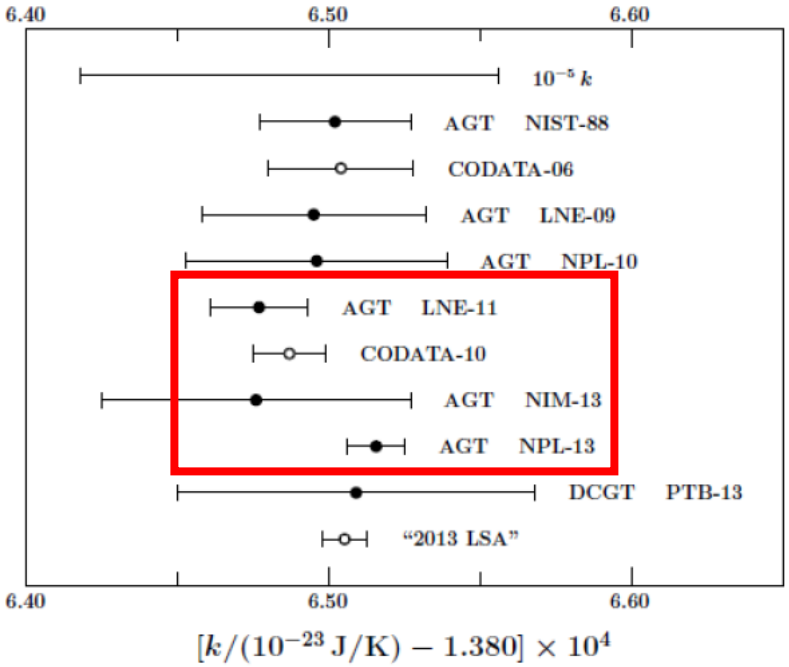
Large differences encountered in AGT between the LNE and NPL:



- LNE: Continued work and studies on molar mass and isotopic composition at KRISS/LNE
- NPL: Transition from determination of the Boltzmann constant to determination of thermodynamic temperatures to determine T-T_{90}.

CCT meeting : Boltzmann constant

Values considered by CODATA in 2013



CODATA cut-off criterion could exclude DCGT for the new k_B